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Radiation Dose in Close Proximity to Patients After Myocardial Perfusion Imaging

Potential Implications for Hospital Personnel and the Public

To the Editor: Myocardial perfusion imaging (MPI) is unique in that patients administered radioactive pharmaceuticals continue to emit radiation following study completion, with potential radiation exposure to others. Despite the wealth of data regarding increasing radiation exposure in patients undergoing medical testing, there are few data regarding radiation exposure in others after MPI. We therefore measured the radiation emitted by patients after undergoing clinical MPI and found that radiation exposure in people in close proximity to the patient in the first few hours after radioisotope injection may be important, particularly in individuals with repeated exposures and/or in vulnerable populations. As expected, there was a large reduction in radiation exposure with small increases in distance, highlighting the importance of the effect of distance on radiation exposure, a key radiation safety principle.

Our methods are outlined in the Online Appendix. We prospectively evaluated data from 56 subjects (mean age: 68 ± 12 years; 37 (66%) men; mean weight: 83 ± 15 kg) referred for single-day technetium (Tc)-99m sestamibi MPI. The mean Tc-99m–administered activity values at rest and during stress were 381 ± 26 MBq and 1,135 ± 80 MBq, respectively. Radiation measurements were obtained in 46 subjects using an ionization chamber (IC) and Geiger-Muller (GM) survey meter at the center of the chest wall; at the right elbow; and at 0.3, 1, and 2 m from the right chest wall immediately after the completion of the MPI study. Additional GM measurements were obtained from inpatients at the time of arrival to the hospital floor (1.51 ± 0.56 h following stress injection) and at 1, 2, and 4 h after arrival. Radiation dose rate data are summarized in Figure 1. Film badge dosimetry was obtained in 10 additional subjects. For an exposure of 27.6 ± 8.1 min beginning at 1.5 h after radionuclide administration, the anterior chest wall dose equivalent was 0.37 ± 0.13 mSv and the right chest wall dose equivalent was 0.58 ± 0.26 mSv.

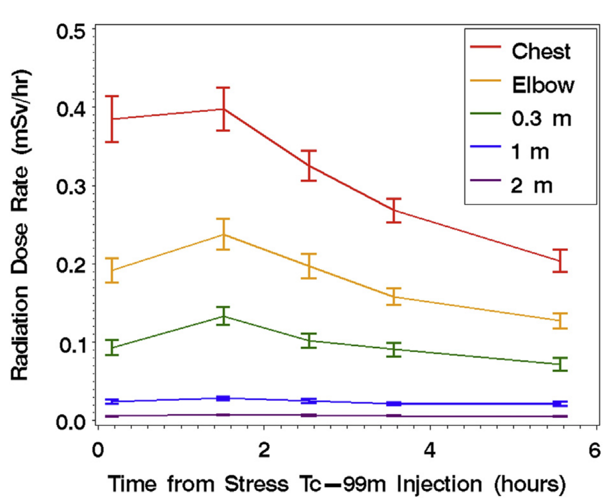

Figure 1 **Mean ± Standard Error Radiation Exposure Rates After Stress technetium (Tc)-99m Radioisotope Injection**

We estimated cardiac sonographer–patient contact time and transport-staff duration with patients at our institution as 24 ± 8 min and 10 ± 6 min, respectively, based on a consecutive review of 64 echocardiographic studies and 44 transportation logs. A right-handed sonographer positioned at the right elbow to chest wall would have a potential radiation dose equivalent of 0.10 to 0.16 mSv at 1.5 h after stress injection. For a left-hand scanning sonographer at 0.3 m, the dose equivalent would be 0.04 mSv. For a transport worker, a 10-min exposure at 0.3 m would impart a dose equivalent of 0.02 mSv. Film badge dosimetry demonstrated an even greater estimate of radiation exposure.

Others have measured radiation exposure in nuclear medicine staff (1–3). These studies have yielded small radiation dose rates, which were greatest with Tc-99m MPI studies and with exposures requiring prolonged close contact. Although dosimeters worn at different locations have been used (2), the measurements may not reflect exposure to sonographers, who are in immediate contact with patients for a prolonged period. Badge position may affect the measurement due to the significant change in exposure rates over small distances. Our patient badges were placed in the location of cardiac sonographers' contact with patients during scanning.

Current practice behavior may increase occupational radiation exposure, with scheduling of multiple same-day tests to expedite hospital discharge or to consolidate outpatient testing for patients' convenience. At our 660-bed medical center, an inpatient is brought from MPI testing to the echocardiography laboratory approximately once daily. At many institutions, transport personnel may be assigned to an area for prolonged periods. Non–nuclear medicine personnel do not receive radiation safety training and may be unaware of the potential risks of radiation exposure and the simple methods of protecting themselves from radiation emitted by patients. Without guidelines in the management and scheduling of post-MPI patients, a sonographer with repeated exposures may approach or exceed the 20-mSv/year (100 mSv/5 yrs) guideline recommendation (4) or the goal of ≤10% of this limit used by many centers. Paradigms to facilitate rotation of exposed staff and scheduling of echocardiographic

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examinations *before* or at least 4 hours *after* MPI are needed. Other services in which medical staff have prolonged close patient contact should occur outside of this window. If rescheduling cannot occur, the use of lead aprons by staff working closely with patients should be considered during the first 4 h following MPI.

Experts have suggested that it is difficult to generate definitive conclusions about the health risks attributable to radiation doses <50 mSv in 1 year or <100 mSv over a lifetime (5). Although it is unlikely that repeated exposure to post-MPI patients will exceed these limits in adults, our data suggest that close and repeated contact should be avoided in populations that are more radiosensitive, such as pregnant women and children.

An estimation of the total effective dose equivalent was not the subject of our study and would be exceedingly challenging given the variability in the time of exposure, distance, and body position. Our measures of radiation exposure are routinely performed by radiation safety departments.

MPI is an important tool in the evaluation of patients for coronary artery disease, providing valuable diagnostic and prognostic information. Current recommendations for the appropriate use of MPI generally limit its use to those patients with at least intermediate risk, inability to exercise, an abnormal baseline electrocardiogram, or other situations in which the risk–benefit ratio is favorable. Our data confirm that radiation exposure to hospital personnel and the public can be minimized by maintaining adequate distance from the patient. Instituting appropriate changes in scheduling, the use of lead shielding, and patient education can further aid in reducing radiation exposure in others.

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APPENDIX

For more details on the methods, as well as supplemental figures, please see online version of this article.

Letters to the Editor

Multidetector Computed Tomography Stress-Rest Perfusion Imaging for Detection of Coronary Artery Disease

Dr. Bettencourt and colleagues compare the diagnostic performance of multidetector computed tomography (MDCT) stress-rest perfusion imaging (using significantly lower dose radiation) with cardiac magnetic resonance myocardial perfusion imaging (CMR-Perf) for detection of functionally significant coronary artery disease with fractional flow reserve (FFR) as reference standard (1).

It would be interesting to know the following. First, did the authors make an attempt to compare performance of computed tomography perfusion (CTP) and CMR-Perf among patients with multivessel disease or those with >70% stenosis? Second, did the authors make an attempt to investigate the lesions labeled "false positive" on CTP, which could be incorrectly labeled as "false positive" in setting of nonobstructive coronaries (due to thrombus recannalization or post-percutaneous coronary intervention)? The authors measured FFR in vessels with >40% stenosis; however, abnormal FFR can be found in vessels with lesser degree of stenosis (2). This is more important in setting of microvascular disease, which has worse prognosis. CTP could be particularly helpful in such scenario due to its high resolution and ability to evaluate parameters of endothelial function and microvascular circulation (3).

Though use of 17-segment model to compare CTP and CMR-Perf is itself not perfect, due to overlap of segments between various coronary territories, the current report is a welcome step in the ongoing search for "1-stop" cardiac imaging modality.

However, an important practical limitation of CTP at this time is need for designated software for image analyses and substantial expertise to interpret images and make accurate diagnoses. Further, as patient population in current study was very selective, it would be interesting to see in future studies how MDCT-integrated protocol performs in "real world."

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